DUDLEY KNOX LIBRARY
NAVAL POSTGRADUATE SCHOOL
MONTEREY, CALIF, 93940

NPG-137

NAVAL POSTGRADUATE SCHOOL
Monterey, California

THESIS

A MANPOWER MODEL TO DETERMINE FUTURE INPUTS TO NEC 335X AND NEC 336X BILLETS

by

Lawrence K. C. Doong

December 1981

Thesis Advisor: Kneale T. Marshall

Approved for public release, distribution unlimited.

T202064

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER

2. GOVT ACCESSION NO.

3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle)
A Manpower Model to Determine Future Inputs to NEC 335X and NEC 336X Billets

5. TYPE OF REPORT & PERIOD COVERED
Master's Thesis
December 1981

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s)
Lawrence K. C. Doong

8. CONTRACT OR GRANT NUMBER(s)

9. PERFORMING ORGANIZATION NAME AND ADDRESS
Naval Postgraduate School
Monterey, California 93940

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS

11. CONTROLLING OFFICE NAME AND ADDRESS
Naval Postgraduate School
Monterey, California 93940

12. REPORT DATE
December 1981

13. NUMBER OF PAGES
74

14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)

15. SECURITY CLASS. (of this report)

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)
Approved for public release, distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)
Manpower Modelling, Nuclear Submarine Propulsion Plant, NEC 335X, NEC 336X, Manpower Requirements, Enlisted Submariners.

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)
This thesis developes a manpower model to determine future inputs of personnel to NEC 335X and 336X billets to support manning levels at 100% of authorized billets. The model utilizes cross sectional data, stocks and flows concepts, a Markov chain transition matrix, and derives future billet requirements in order to determine desired stock levels and input projections, by pay-grade, up to 1990. By comparing billet requirements to on hand stocks in the out years, an analysis of personnel utilization

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 68 IS OBSOLETE
S/N 0102-014-6601

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

Block 20 (continued)

reveals overmanning in the E6 paygrades for NEC 335X, and overmanning in the E7, E8, and E9 paygrades for NEC 336X. The analysis suggests a reassignment of junior billets to senior personnel or an increase of senior billet authorization. This model is applicable to virtually any rate, rating or NEC within the enlisted personnel structure.

Approved for public release, distribution unlimited.

A Manpower Model to Determine Future Inputs to NEC 335X and NEC 336X Billets

by

Lawrence K. C. Doong
Lieutenant, United States Navy
B.S., United States Naval Academy, 1976

Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN MANAGEMENT

from the

NAVAL POSTGRADUATE SCHOOL
December 1981

ABSTRACT

This thesis developes a manpower model to determine future inputs of personnel to NEC 335X and 336X billets to support manning levels at 100% of authorized billets. The model utilizes cross sectional data, stocks and flows concepts, a Markov chain transition matrix, and derives future billet requirements in order to determine desired stock levels and input projections, by paygrade, up to 1990. By comparing billet requirements to on hand stocks in the out years, an analysis of personnel utilization reveals overmanning in the E6 paygrades for NEC 335X, and overmanning in the E7, E8, and E9 paygrades for NEC 336X. The analysis suggests a reassignment of junior billets to senior personnel or an increase of senior billet authorization. This model is applicable to virtually any rate, rating or NEC within the enlisted personnel structure.

TABLE OF CONTENTS

I. INTRODUCTION ---------- 9

A. BACKGROUND ---------- 9

B. PROBLEM ---------- 10

C. OBJECTIVE ---------- 14

II. SUBMARINER MANPOWER INPUT MODEL ---------- 15

A. INTRODUCTION ---------- 15

B. MODEL DESCRIPTION ---------- 15

1. General Information ---------- 15

2. Variables Required for NEC 335X ---------- 16

3. Variables Required for NEC 336X ---------- 17

4. Fractional Flow Modelling ---------- 18

III. MODEL DESCRIPTION ---------- 21

A. DERIVATION OF Q-MATRIX ---------- 21

1. NEC 335X Personnel Matrix ---------- 21

2. NEC 336X Personnel Matrix ---------- 28

B. DERIVATION OF REQUIREMENTS VECTOR ---------- 33

C. MODEL OBJECTIVE ---------- 36

IV. MODEL APPLICATION ---------- 37

A. INTRODUCTION ---------- 37

B. BILLET REQUIREMENTS PROJECTION ---------- 37

1. Sea Billets ---------- 37

2. Shore Billets ---------- 40

3. Total Billet Requirements ---------- 45

C. INPUT REQUIREMENTS ---------- 45
D. STOCK DETERMINATION ---------- 49
E. EXPLANATION OF FINDINGS ---------- 54
1. NEC 335X Personnel ---------- 54
2. NEC 336X Personnel ---------- 55
V. CONCLUSIONS ---------- 56
APPENDIX A - SEA BILLET AUTHORIZATIONS ---------- 59
LIST OF REFERENCES ---------- 73
INITIAL DISTRIBUTION LIST ---------- 74

LIST OF TABLES

I. FISCAL YEAR 1981, NEC 335X ENLISTED PERSONNEL DATA ---------- 22

II. LOSSES OF NEC 335X PERSONNEL, FISCAL YEAR 1981 -- 24

III. NEC 335X ENLISTED PERSONNEL DATA MATRIX --------- 26

IV. Q-MATRIX, NEC 335X ---------- 27

V. FISCAL YEAR 1981, NEC 336X ENLISTED PERSONNEL DATA ---------- 29

VI. LOSSES OF NEC 336X PERSONNEL, FISCAL YEAR 1981 -- 30

VII. NEC 336X ENLISTED PERSONNEL DATA MATRIX --------- 31

VIII. Q-MARTIX, NEC 336X ---------- 32

IX. BILLET REQUIREMENTS BY PAYGRADE FOR NEC 335X AS OF JULY 1981 ---------- 34

X. BILLET REQUIREMENTS BY PAYGRADE FOR NEC 336X AS OF JULY 1981 ---------- 35

XI. NUCLEAR SUBMARINE INVENTORY PROJECTIONS --------- 38

XII. SEA/SHORE BILLETS FOR NEC 335X and 336X, 1981 --- 41

XIII. SEA BILLET PROJECTIONS FOR NEC 335X/336X -------- 42

XIV. SHORE DUTY PROJECTIONS FOR NEC 335X/336X -------- 44

XV. TOTAL BILLET REQUIREMENTS PER YEAR FOR NEC 335X PERSONNEL ---------- 46

XVI. TOTAL BILLET REQUIREMENTS PER YEAR FOR NEC 336X PERSONNEL ---------- 47

XVII. PROJECTED STOCK LEVELS PER YEAR FOR NEC 335X PERSONNEL ---------- 50

XVIII. PROJECTED INPUT REQUIREMENTS PER YEAR FOR NEC 335X PERSONNEL ---------- 51

XIX. PROJECTED STOCK LEVELS PER YEAR FOR NEC 336X PERSONNEL ---------- 52

XX. PROJECTED INPUT REQUIREMENTS PER YEAR FOR NEC 336X PERSONNEL ---------- 53

A-I. BILLET AUTHORIZATIONS FOR SSN 575 CLASS --------- 60

A-II. BILLET AUTHORIZATIONS FOR SSN 578 CLASS --------- 61

A-III. BILLET AUTHORIZATIONS FOR SSN 585 CLASS --------- 62

A-IV. BILLET AUTHORIZATIONS FOR SSN 594 CLASS --------- 63

A-V. BILLET AUTHORIZATIONS FOR SSN 597 CLASS --------- 64

A-VI. BILLET AUTHORIZATIONS FOR SSN 598 CLASS --------- 65

A-VII. BILLET AUTHORIZATIONS FOR SSN 608 CLASS --------- 66

A-VIII. BILLET AUTHORIZATIONS FOR SSN 637 CLASS --------- 67

A-IX. BILLET AUTHORIZATIONS FOR SSN 671 CLASS --------- 68

A-X. BILLET AUTHORIZATIONS FOR SSN 685 CLASS --------- 69

A-XI. BILLET AUTHORIZATIONS FOR SSN 688 CLASS --------- 70

A-XII. BILLET AUTHORIZATIONS FOR SSBN 616 CLASS -------- 71

A-XIII. BILLET AUTHORIZATIONS FOR SSBN 726 CLASS -------- 72

I. INTRODUCTION

A. BACKGROUND

Manpower has, is, and will continue to be of major concern in support of an all-volunteer military force in the United States. Increasing the overall strength of the military in fulfilling its mission to defend and protect the United States has come at a time when youth quantity and quality are in dwindling supplies. Manning the Armed Forces at an approximate strength of two million personnel encounters numerous obstacles that must be examined in order to facilitate viability of maintaining a volunteer military.

Under the Reagan administration, the United States Navy alone will be tasked with manning a fifteen battle group force. While this incorporates an increase in hardware, the Navy must seriously approach the issue of obtaining the required numbers of personnel to effectively carry out its new role and increased task. In moving to a fifteen battle group Navy, ships of various classes will be built, modified, and increased. Of particular interest to the author is the increase in the United States Naval Submarine forces. Although an increase in hardware for the submarine forces is of a minimal percentage, 19%, the manning of the submarine forces requires particular attention.

This thesis examines the manning of just one facet of a fifteen battle group Navy - the enlisted personnel of the United States Submarine forces, in particular, a specialized group of engineers and technicians coded with a particular Navy Enlisted Classification (NEC).

An NEC is a Navy Enlisted Classification which supplements the enlisted rating structure in identifying personnel on active or inactive duty and billets in manpower authorizations. NEC codes reflect special knowledge and skills that identify personnel and requirements when the rating structure is insufficient by itself for manpower management purposes. The NEC coding system facilitates management control over enlisted skills by identifying billets and personnel and enhances efficient utilization of personnel in distribution and detailing. In cases where NECs reflect special training, inventories of coded personnel are also the basis for planning and controlling input of personnel into formal courses that earn NECs. Consequently, the continuing enlisted strength of the Navy, particularly petty officer allocations, and funds authorized for rating and specialty training depends to an increasing extent upon the accuracy, thoroughness, and timeliness of NEC coding [Ref. 1].

B. PROBLEM

While the macroscopic issues concern methods of manning the military throughout the 1980s and 1990s, this thesis

subdivides the issue to a micro-oriented aspect of manning two series of NECs associated with nuclear submariners. These series are the 335X series and the 336X series. The 335X series embodies the 3351, 3353, 3354, 3355, 3356, and 3359 NECs that are applicable to submarine nuclear propulsion plant operators. On the other hand, the 336X series includes the 3361, 3363, 3364, 3365, and 3366 NECs that are applicable to submarine nuclear propulsion plant supervisors. The following extract from the Manual of Navy Enlisted Manpower and Personnel Classifications and Occupational Standards provides an explanation of each NEC:

3351: Submarine Nuclear Propulsion Plant Operator - Welder
Performs duties associated with NEC 3355 and performs emergency weld repairs on propulsion plant piping and components.
Source rating: Machinist Mate (MM)

3353: Submarine Nuclear Propulsion Plant Operator - Reactor Control
Operates and performs organizational level maintenance on reactor control systems for submarine nuclear propulsion plants.
Source rating: Electronics Technician (ET)

3354: Submarine Nuclear Propulsion Plant Operator - Electrical
Operates and performs organizational level maintenance on electrical systems for submarine nuclear propulsion plants.
Source ratings: Interior Communications (IC), Electricians Mate (EM)

3355: Submarine Nuclear Propulsion Plant Operator - Mechanical
Operates and performs organizational level maintenance on mechanical systems for submarine nuclear propulsion plants.
Source ratings: Machinist Mate (MM), Engineman (EN)

3356: Submarine Nuclear Propulsion Plant Operator - Engineering Laboratory Technician

Performs duties associated with NECs 3353, 3354, or 3355. Performs radiological controls and water chemistry control functions and associated analysis for submarine nuclear propulsion plants.

Source ratings: Machinist Mate (MM), Engineman (EN), Interior Communications (IC), Electricians Mate (EM)

Note: Currently only personnel in MM source rating are being accepted.

3359: Submarine Nuclear Propulsion Plant Operator - Special Category

Performs duties as required in current duty assignment.

Source ratings: Electronics Technician (ET), Interior Communications (IC), Electricians Mate (EM), Engineman (EN), Machinist Mate (MM)

Note: Previously qualified for any 335X NEC but not currently assigned to a nuclear propulsion plant operator billet.

3361: Submarine Nuclear Propulsion Plant Supervisor - Welder

Source rating: Machinist Mate (MM)

Note: Specified Watchstations are:

E5/6: Engineroom Supervisor and Shutdown Roving Watch

E7/8/9: Not applicable

3363: Submarine Nuclear Propulsion Plant Supervisor - Reactor Control

Source rating: Electronics Technician (ET)

Note: Specified Watchstations are:

E5/6: Reactor Operator and Shutdown Reactor Operator

E7/8/9: Engineering Watch Supervisor

3364: Submarine Nuclear Propulsion Plant Supervisor - Electrical

Source Ratings: Interior Communications (IC), Electricians Mate (EM)

Note: Specified Watchstations are:

E5/6: Electrical Operator and Shutdown Reactor Operator

E7/8/9: Engineering Watch Supervisor

3365: Submarine Nuclear Propulsion Plant Supervisor - Mechanical
Source ratings: Machinist Mate (MM), Engineman (EN)
Note: Specified Watchstations are:
E5/6: Engineroom Supervisor and Shutdown Roving Watch
E7/8/9: Engineering Watch Supervisor

3366: Submarine Nuclear Propulsion Plant Supervisor - Engineering Laboratory Technician
Source ratings: Electricians Mate (EM), Engineman (EN), Machinist Mate (MM), Interior Communications (IC)
Note: (1) Currently only personnel in MM source rating are being accepted.
(2) Specified Watchstations are:
E5/6: Engineering Laboratory Technician and
(1) Engineroom Supervisor and Shutdown Roving Watch (MM, EN), or
(2) Electrical Operator and Shutdown Reactor Operator (EM, IC)
E7/8/9: Engineering Watch Supervisor

[Ref. 1:68-71].

From the above synopsis, it can be seen that the 335X are more suited to junior billets while senior enlisted obtain the 336X NEC series.

This thesis is concerned with forecasting the manpower input requirements needed in order to fill these billets to a 100% manning level throughout the remainder of the 1980s. This is done by developing an interactive manpower input model that is designed to forecast the numbers and types of personnel required to become a 335X or 336X coded personnel in the out years.

C. OBJECTIVE

While the manpower model being developed deals directly with two series of NECs, the procedures would be applicable to virtually any rating or NEC. Since submariners are supposedly manned to 100% at any particular time, a more important aspect to consider may be the impact this policy has on the manning of the remainder of the fleet. The model incorporates many underlying assumptions that will be revealed in the design process. The "submariner manpower input model," as it will be referred to, is designed to structure different aspects that affect manpower input requirements and provide manpower planners with only one of many methods for considering manpower needs.

II. SUBMARINER MANPOWER INPUT MODEL

A. INTRODUCTION

During an era when manpower resources are on a decreasing trend, the all-volunteer military, more than any other sector of society, must turn to methods of increasing effectiveness of utilizing its personnel. While acquisition of new personnel surfaces as a major concern, retention of trained, qualified individuals lies in waiting with equal importance. The defense establishment maintains an essentially closed heirarchical system with most accessions appearing in the lowest enlisted ranks. In the case of the Naval submariner, manpower inputs begin at the E1 paygrades and proceed through a series of specialized training pipelines prior to reporting to their first command with a specialty rating. The purpose of the submariner manpower input model is to examine the movement of personnel within a specified time frame.

B. MODEL DESCRIPTION

1. General Information

The submariner manpower input model utilizes a cross-sectional structure where knowledge of historic personnel movement older than one time period is not required. The model incorporates the concepts of stocks and flows in accounting personnel data during a specified time period.

To this end, let $s_i(t)$ be the stock of personnel in a designated NEC in paygrade i at time t. Let s(t) be an N vector with i-th element equal to $s_i(t)$, where i = 1,2,...,N.

Flows of personnel, on the other hand, are referred to by the notation, $f_i(t)$. This notation describes the number of personnel flowing into class i during time period t, where i again signifies paygrade.

The submariner manpower input model additionally utilizes the concept of a Q-matrix. The Q-matrix is the basic fractional flow matrix that partitions the stock of manpower in class i into fractions that flow into each class j. The Q-matrix possesses N X N dimensions and is composed of q_{ji} elements where q_{ji} is the fraction of personnel that are in paygrade i at time t that are in paygrade j at time t+1. Each element q_{ji} describes the historical movement of personnel during one time period.

2. Variables Required for NEC 335X

Throughout the ensuing discussion, subscript i depicts the associated paygrades where i equals paygrades i+3, i.e. i=1 describes paygrade E4, i=2 describes paygrade E5,..., i=6 describes paygrade E9.

a. $$f(t) = \begin{pmatrix} f_1(t) \\ f_2(t) \\ f_3(t) \\ f_4(t) \\ f_5(t) \\ f_6(t) \end{pmatrix} .$$

The flow variable depicts a 6 X 1 column vector representing the flows of personnel into each paygrade during period t.

b.

$$s(t) = \begin{pmatrix} s_1(t) \\ s_2(t) \\ s_3(t) \\ s_4(t) \\ s_5(t) \\ s_6(t) \end{pmatrix} .$$

The stock vector also features a 6 X 1 column vector depicting inventories of personnel in each paygrade at time t.

c.

$$r(t) = \begin{pmatrix} r_1(t) \\ r_2(t) \\ r_3(t) \\ r_4(t) \\ r_5(t) \\ r_6(t) \end{pmatrix} .$$

The requirements vector depicts the total requirements, both sea duty and shore duty billets, in paygrades i at time t.

d.

$$Q = \begin{bmatrix} q_{11} & \cdots & q_{16} \\ \vdots & & \vdots \\ q_{61} & \cdots & q_{66} \end{bmatrix}$$

Finally, the Q-matrix depicts a 6 X 6 matrix illustrating the movement of personnel within a time period. For example, element q_{33} describes personnel who remain E6 during one time period while q_{43} depict personnel who were E6 at the start of the accounting period and were promoted to E7 by the end of the period.

3. Variables Required for NEC 336X

Variable notation for 336X personnel are similar as the convention applied to 335X personnel except that the E4 paygrade is eliminated. Therefore, subscript i represents paygrades

for i+4. The following vectors and matrix are applicable to 336X personnel with descriptions as mentioned previously:

a. $$f(t) = \begin{pmatrix} f_1(t) \\ f_2(t) \\ f_3(t) \\ f_4(t) \\ f_5(t) \end{pmatrix}$$

b. $$s(t) = \begin{pmatrix} s_1(t) \\ s_2(t) \\ s_3(t) \\ s_4(t) \\ s_5(t) \end{pmatrix}$$

c. $$r(t) = \begin{pmatrix} r_1(t) \\ r_2(t) \\ r_3(t) \\ r_4(t) \\ r_5(t) \end{pmatrix}$$

d. $$Q = \begin{bmatrix} q_{11} & \cdots & q_{15} \\ \vdots & & \vdots \\ q_{51} & \cdots & q_{55} \end{bmatrix}$$

4. Fractional Flow Modelling

The basic fractional flow model incorporates the following equation:

$$s(t) = Qs(t-1) + f(t) \qquad \text{EQ 1}$$

In other words, the stocks of personnel in any given time period may be determined by multiplying the fractional flow matrix by the column vector of stocks at time (t-1) and increasing these figures by the flows of personnel into each class of stocks at time t. The model is shown to be cross-sectional in that it ignores all stocks and flows of personnel prior to time t-1 and uses the cross-sectional data s(t-1). Essentially, the stocks of personnel in a specific time period

are determined by the legacy left over from previous time periods and vector of new appointments in time t [Ref. 2].

Illustrating Equation 1 and maintaining conservation of flow relationships, (using 336X data as an example):

$$\begin{pmatrix} s_1(t) \\ s_2(t) \\ s_3(t) \\ s_4(t) \\ s_5(t) \end{pmatrix} = \begin{bmatrix} q_{11} & q_{12} & q_{13} & q_{14} & q_{15} \\ q_{21} & q_{22} & q_{23} & q_{24} & q_{25} \\ q_{31} & q_{32} & q_{33} & q_{34} & q_{35} \\ q_{41} & q_{42} & q_{43} & q_{44} & q_{45} \\ q_{51} & q_{52} & q_{53} & q_{54} & q_{55} \end{bmatrix} X \begin{pmatrix} s_1(t-1) \\ s_2(t-1) \\ s_3(t-1) \\ s_4(t-1) \\ s_5(t-1) \end{pmatrix} + \begin{pmatrix} f_1(t) \\ f_2(t) \\ f_3(t) \\ f_4(t) \\ f_5(t) \end{pmatrix} \quad \text{EQ 2}$$

Another assumption inherent in the model is that personnel advance one grade at a time and does not allow for demotions. This results in the Q-matrix taking the form of a triangular matrix with data concentrated along the two main negatively sloped diagonals (q_{11} to q_{66} and q_{21} to q_{65}). The Q-matrix will be assumed to remain constant over time meaning the Q-matrix will be representative of personnel movements within any period.

The final set of calculations required for the model is a manipulation of Equation 1. Notably, it might be more important to determine the flows of personnel into each pay-grade necessary to attain the required stock levels at some time t:

$$f(t) = r(t) - Qs(t-1) \quad \text{EQ 3}$$

Essentially, the flows of personnel at any time t may be determined by subtracting the number of personnel remaining from previous time periods from the number of personnel required to fill total billets in the present time period. A major assumption at this point is that all feasible input vectors must be non-negative. Requirements can only be met

by new appointments and forced attrition is not allowed. Any negative input vector will hereby be replaced by a zero indicating that no new inputs are necessary to attain the desired stock level to meet requirements.

Through a series of manipulations and substitutions, the flows at any time period may be calculated as shown:

(i) $f(t) = r(t) - Qs(t-1)$

(ii) $s(t) = f(t) + Qs(t-1)$

This series would be conducted for each time period through 1990.

III. MODEL DESCRIPTION

A. DERIVATION OF Q-MATRIX

In developing the basic fractional flow Q-matrix, separate personnel data was compiled for submariners with a primary NEC of 335X and those with a primary NEC of 336X. Each data set contained beginning strengths, losses, gains and end strengths for each paygrade during the fiscal year 1981. Beginning strengths define the total number of personnel with the designated NEC at the start of the accounting period, categorized by paygrade. Losses account for all personnel that exit the present paygrade due to a change in paygrade, change in NEC, separation from service, administration errors, or loss of NEC. For purposes of this thesis, it is imperative that changes in NEC fall into one of two categories: a change from NEC 335X to 336X and vice versa, or a change in NEC from 335X/336X to any other NEC. Gains characterize personnel entering a paygrade during the accounting period through promotion, new accession or a cross-rate transfer (change in NEC). Finally, end strengths describe personnel accountable by paygrade at the end of the fiscal year who hold the designated NEC.

1. NEC 335X Personnel Matrix

Data pertinent to all submariners with a 335X NEC is depicted in Table I. Prior to examining the data of Table I, several points require consideration. Access to a 335X NEC

TABLE I

FISCAL YEAR 1981, NEC 335X ENLISTED PERSONNEL DATA

Category \ Rank	E4	E5	E6	E7	E8	E9
Beginning Strength	1086	4301	795	162	90	35
Losses	838	1769	523	89	38	15
Gains	675	1560	844	79	34	13
End Strength	923	4092	1127	152	86	33

(Data provided by Defense Manpower Data Center)

(with the exception of NEC 3359) is limited to a minimum paygrade of E4 and a maximum paygrade of E5 (NEC 3359 minimum is E4 and a maximum of E9). In this regard, new accessions are bound by entry to paygrades E4 and E5. Access to a 335X NEC at the upper paygrades are through NEC 336X reclassifications procedures.

During an accounting period, personnel are listed as losses for several reasons. Table II provides a breakdown of various categories for which personnel are counted as losses.

Utilizing the data from Tables I and II, the elements necessary for the construction of the Q-matrix may be computed using the following methods:

$$\frac{\text{Beginning strength of a given paygrade} - \text{Number of losses in that paygrade}}{\text{Number of personnel remaining in that paygrade}} \quad \text{EQ 4}$$

$$\frac{\text{Number of losses in a given paygrade} - \text{Number of personnel promoted to the next paygrade}}{\text{Number of personnel forfeiting rank and NEC 335X}} \quad \text{EQ 5}$$

Calculation of gains for a given paygrade involves two separate procedures. For E4s and E5s, gains are comprised of new accessions, promotions from a lower rank with NEC 335X, promotions from a lower rank of personnel changing NECs from 336X to 335X, personnel remaining at the given paygrade but changing NEC from 336X to 335X. For example,

$$\frac{\text{NEC 335X E4 promotions to next paygrade} + \text{NEC 336X changes to NEC 335X E4 promotions} * + \text{NEC 336X changes to NEC 335X E5 personnel} * + \text{New accessions}}{\text{E5 gains NEC 335X}} \quad \text{EQ 6}$$

*Note: 336X data from Table VI

TABLE II

LOSSES OF NEC 335X PERSONNEL, FISCAL YEAR 1981

Category \ Paygrade	E4	E5	E6	E7	E8	E9
Beginning Strength	1086	4301	795	162	90	35
# Remaining in Grade with NEC 335X	248	2532	272	73	52	20
# Promoted to Next Grade with NEC 335X	636	764	41	6	7	-
# Demoted but Retaining NEC 335X	12	29	0	0	0	0
# Remaining in Paygrade but NEC Changed to 336X	0	20	240	56	17	4
# Promoted but Changing NEC to 336X	1	223	12	3	0	-
# Changing to Other NEC	95	89	9	7	0	0
Service Losses	60	551	219	17	14	11
Loss of NEC	34	82	2	0	0	0

(Data Provided by Defense Manpower Data Center)

In the second situation for E6 and above, gains are similar except that new accessions are not included.

NEC335X E5 promotions
+NEC 336X changes to NEC 335X E5 promotions EQ 7
+NEC 336X changes to NEC 335X E6 personnel
E6 gains NEC 335X

By using the previous formulas and data, Table III was developed as the raw data for the basic fractional flow matrix.

Table III describes total personnel movement for FY 1981. Taking E4s as an example, Table III shows that 248 E4s remained E4s during FY 81, 636 E4s were promoted to E5 and 228 E4s were lost from the accounting period as E4s with NEC 335X. Similar explanations are applicable to the remaining paygrades. Table III acts as a build-up to the basic fractional flow Q-matrix as shown in Table IV. The net loss row is not normally an element of the Q-matrix but has been included for simplicity in understanding and completeness of the matrix.

As can be seen from the matrix in Table IV, the Q-matrix is simply a matrix of fractions describing one step movements in a fiscal year accounting period. In demonstrating a sample calculation, E4s will again be examined: 22.8% of E4s remain E4s, 58.6% of E4s are promoted to E5s, and 18.6% of E4s with NEC 335X are lost during the accounting period. The formulas used for these computations are as follows:

$$\frac{\text{Number of personnel remaining in a given paygrade}}{\text{Beginning strength of that paygrade}} \quad \text{EQ 8}$$

$$\frac{\text{Number of personnel promoted from a given paygrade}}{\text{Beginning strength of that paygrade}} \quad \text{EQ 9}$$

TABLE III

NEC 335X ENLISTED PERSONNEL DATA MATRIX

Paygrade 81 \ Paygrade 80	E4	E5	E6	E7	E8	E9
E4	248	0	0	0	0	0
E5	636	2532	0	0	0	0
E6	0	764	272	0	0	0
E7	0	0	41	73	0	0
E8	0	0	0	6	52	0
E9	0	0	0	0	7	20
Net Loss	228	1004	482	83	31	15

TABLE IV

Q-MATRIX, NEC 335X

Paygrade 81 \ Paygrade 80	E4	E5	E6	E7	E8	E9
E4	.228	0	0	0	0	0
E5	.586	.589	0	0	0	0
E6	0	.178	.342	0	0	0
E7	0	0	.052	.451	0	0
E8	0	0	0	.037	.578	0
E9	0	0	0	0	.078	.571
Net Loss	.186	.233	.606	.512	.344	.429

$$\frac{\text{Net losses from a given paygrade}}{\text{Beginning strength of that paygrade}} \qquad \text{EQ 10}$$

2. NEC 336X Personnel Matrix

The derivation of the Q-matrix for enlisted personnel with NEC 336X is identical as that for the 335X series except that there are no E4 personnel for reasons stated previously. NEC 336X is normally assigned to senior enlisted nuclear billets (Petty Officer Second Class and above) who have completed six or more years active Naval service and qualified in specific watchstations.

The pertinent data for NEC 336X personnel are depicted in Table V, followed by a categorization of losses listed in Table VI.

Example of calculations (using E8 data):

Beginning strength	180	
-Number of losses	51	
Number of E8s remaining E8	129	
Number of losses	51	
-Number of promotions to E9	9	
Number of E8s lost from paygrade with NEC 335X		
NEC 336X promotions to E9	9	
+NEC 335X changes to 336X E8 promotions	0	*
+NEC 335X changes to 336X E9 personnel	4	*
E9 gains for NEC 336X	13	

*Note: Taken from Table II

Utilizing the above calculations for each paygrade, Table VII was derived followed by the Q-matrix transformation leading to Table VIII. Notice again that in Table VIII, net

TABLE V

FISCAL YEAR 1981, NEC 336X ENLISTED PERSONNEL DATA

Category \ Rank	E5	E6	E7	E8	E9
Beginning Strength	33	1102	612	180	48
Losses	29	534	159	51	13
Gains	21	491	221	75	13
End Strength	28	1068	679	206	48

(Data provided by Defense Manpower Data Center)

TABLE VI

LOSSES OF NEC 336X PERSONNEL, FISCAL YEAR 1981

Category \ Paygrade	E5	E6	E7	E8	E9
Beginning Strength	33	1102	612	180	48
# Remaining in Grade with NEC 336X	4	568	453	129	35
# Promoted to Next Grade with NEC 336X	18	153	55	9	-
# Demoted but Retaining NEC 336X	0	4	0	0	0
# Remaining in Paygrade but NEC Changed to 335X	0	72	23	24	3
# Promoted by Changing NEC to 335X	8	16	4	3	0
# Changing to Other NEC	1	4	2	1	0
Service Losses	2	281	71	14	10
Loss of NEC	0	4	4	0	0

(Data provided by Defense Manpower Data Center)

TABLE VII

NEC 336X ENLISTED PERSONNEL DATA MATRIX

Paygrade 81 \ Paygrade 80	E5	E6	E7	E8	E9
E5	4	0	0	0	0
E6	18	568	0	0	0
E7	0	153	453	0	0
E8	0	0	55	129	0
E9	0	0	0	9	35
Net Loss	11	381	104	42	13

TABLE VIII

Q-MATRIX, NEC 336X

Paygrade 81 \ Paygrade 80	E5	E6	E7	E8	E9
E5	.121	0	0	0	0
E6	.546	.515	0	0	0
E7	0	.139	.740	0	0
E8	0	0	.090	.717	0
E9	0	0	0	.050	.729
Net Loss	.333	.346	.170	.233	.271

losses are not normally part of the Q-matrix but is included for completeness of the matrix.

B. DERIVATION OF REQUIREMENTS VECTOR

The total requirements at any one time concerns the number of authorized billets that must be filled in that time period. As practiced in the nuclear submarine community, the goal will be to fill 100% of all authorized billets. These billets are composed of both sea and shore billets and are assumed to increase or decrease as the size of the seagoing submarine force expands or contracts. In this respect, billet requirements will increase in proportion to new construction submarines. As more Los Angeles and Ohio class submarines are introduced to the fleet, the numbers of 335X and 336X personnel required to man these vessels will increase.

Tables IX and X provide the billet requirements by paygrade for NEC 335X and 336X respectively. This data is current as of July 1981 and utilized by OP-114. Several notes need to be made concerning these tables. NEC 3359 is a shore duty billet and has no at-sea requirements. Other than NEC 3359, there are no E6 and above billets authorized for NEC 335X. On the other hand, NEC 336X is weighted toward the upper level paygrades. The fundamental reason for this is that NEC 335X is an operator billet leading to a supervisory series in a 336X NEC. The totals row becomes the requirements vector for the base year, 1981.

TABLE IX

BILLET REQUIREMENTS BY PAYGRADE FOR NEC 335X AS OF JULY 1981

NEC	RATE	E4	E5	E6	E7	E8	E9	TOTALS
3351	MM		164					164
3353	ET	298	575					873
3354	EM	299	400					
3354	IC	163	175					1037
3355	MM	565	519					1084
3356	MM		569					569
3359	MM		5	79	44	19	18	
3359	EM		8	63	43	11	9	
3359	IC			13	9			
3359	ET			29	26	5	1	382
TOTALS		1325	2415	184	122	35	28	

(Data from OP-114 PNEC/SNEC Billet Requirements/Personnel Inventory Report)

TABLE X

BILLET REQUIREMENTS BY PAYGRADE FOR NEC 336X AS OF JULY 1981

NEC	RATE	E5	E6	E7	E8	E9	TOTALS
3361	MM		165				165
3363	ET	2	403	222	10	10	647
3364	EM	2	618	108	108	5	
3364	IC	1	174	8	6		1030
3365	MM		709	227	189	9	1134
3366	EM		1				
3366	MM	3	492	33	2	14	545
TOTALS		8	2562	598	315	38	

(Data from OP-114 PNEC/SNEC Billet Requirements/Personnel Inventory Report)

Mathematically, for NEC 335X

$$r(81) = \begin{pmatrix} 1325 \\ 2415 \\ 184 \\ 122 \\ 35 \\ 38 \end{pmatrix} ,$$

and for NEC 336X

$$r(81) = \begin{pmatrix} 8 \\ 2562 \\ 598 \\ 315 \\ 38 \end{pmatrix} .$$

Taking the r(81) for NEC 336X as an example, total requirements for NEC 336X is composed of 8 E5 billets, 2562 E6 billets, 598 E7 billets, 315 E8 billets and 38 E9 billets. Beginning with 1982 and outward, billet requirements will increase depending upon the number of new construction submarines being manned in any one time period.

C. MODEL OBJECTIVE

Utilizing the aforementioned information as building blocks, the model incorporates the various variables in an effort to determine the numbers and types of personnel necessary to fill the 335X NEC and 336X NEC billets from 1981 to 1990. This will be the amount of personnel required to join the fleet following completion of all specialty schools and submarine training pipelines. It is upon this objective that the submariner manpower input model is developed.

IV. MODEL APPLICATION

A. INTRODUCTION

The submariner manpower input model is used in a series of steps encompassing present billet requirements, personnel inventories, submarine inventories, and a Q-matrix in order to project the number of personnel required to fill those billets at 100% manning levels. Nuclear submarine inventory projections until 1990 are provided in Table XI. All manpower projections depend upon the accuracy of these projections since billets will increase/decrease in relation to submarine inventories.

B. BILLET REQUIREMENTS PROJECTION

1. Sea Billets

In order to determine the increases and decreases in billet requirements in the outyears, several conventions have been established. Appendix A lists billet authorizations by class of submarines. Taking the authorized number of billets by paygrade and multiplying this by the number of submarines in each class yields the total number of sea billets authorized per class. Summing over all classes yields the total number of sea billets required to be filled each year.

Example of calculations: (using SSN-688 data from Appendix A)

TABLE XI

NUCLEAR SUBMARINE INVENTORY PROJECTIONS

Class \ Year	81	82	83	84	85	86	87	88	89	90
SSN 575	1	1	1	-	-	-	-	-	-	-
SSN 578	4	4	4	3	2	1	-	-	-	-
SSN 585	5	5	5	5	5	5	5	5	5	5
SSN 594	13	13	13	13	13	13	13	13	13	13
SSN 597	1	1	1	1	1	1	1	1	1	1
SSN 598	3	3	3	3	3	3	3	3	3	3
SSN 608	5	5	5	5	5	5	5	5	5	5
SSN 637	37	37	37	37	37	37	37	37	37	37
SSN 671	1	1	1	1	1	1	1	1	1	1
SSN 685	1	1	1	1	1	1	1	1	1	1
SSN 688	14	16	19	24	28	31	34	37	40	40
SSBN 616	31	31	31	31	31	31	31	31	31	31
SSBN 726	1	2	3	4	5	5	6	7	8	9

(i) # of 335X billets per submarine in SSN 688 class

E4 = 6
E5 = 13
E6 = 0
E7 = 0
E8 = 0
E9 = 0

(ii) # of 336X billets per submarine in SSN 688 class

E5 = 0
E6 = 16
E7 = 2
E8 = 2
E9 = 0

(iii) # of SSN 688 class submarines in 1985 (see Table XI)

28

(iv) # of sea billets in 1985 for SSN 688 class

$$\begin{pmatrix} 6 \\ 13 \\ 0 \\ 0 \\ 0 \\ 0 \end{pmatrix} \times 28 = \begin{pmatrix} 168 \\ 364 \\ 0 \\ 0 \\ 0 \\ 0 \end{pmatrix}$$

$$\begin{pmatrix} 0 \\ 16 \\ 2 \\ 2 \\ 0 \end{pmatrix} \times 28 = \begin{pmatrix} 0 \\ 448 \\ 56 \\ 56 \\ 0 \end{pmatrix}$$

Essentially, in 1985, there will be 168 E4 335X NEC sea billets, 364 E5 335X NEC sea billets, 448 E6 336X NEC sea billets, 56 E7 336X NEC sea billets, and 56 E8 336X NEC sea billets onboard the SSN 688 class of submarines. This same procedure would be performed on the remaining classes of submarines and totalled for a final sea billet requirements figure. Increases or decreases in sea duty billets for individual NECs may be easily calculated through this method.

2. Shore Billets

Shore billet determination was established for purposes of the model. Data was not readily available to the author that explicitly segmented shore duty billets by NEC and pay-grade. Available data did, however, indicate that shore billets tend more toward the senior enlisted 336X personnel than for the 335X personnel. Altogether, there were 1513 shore billets compared to 6117 sea billets for 335X and 336X coded personnel in 1981 [Ref. 3]. The assumption to be made at this point is that shore billets will remain relatively proportional to sea billets in the next ten years. This means that the ratio 1513/6117 will be preserved throughout the process of increasing shore billets relative to sea billets. Table XII depicts the 1981 sea/shore billet division as grouped by operator-supervisor combinations. Data on sea/shore break-downs was only available in the format shown, so several additional assumptions must be made. The percentage of shore billets shown in Table XII is assumed to remain constant. It is assumed that the 3353/3363 NEC personnel will maintain 14.9% of the shore billets, regardless of the increase in total shore billets. The same assumption holds true for other NECs.

In order to project shore duty increases, each total from Table XIII was multiplied by (1513/6117) in order to be consistent with the previous assumption of maintaining a constant shore/sea ratio in the out years. This figure would yield the total amount of shore billets for that year. In

TABLE XII

SEA/SHORE BILLETS FOR NEC 335X AND 336X, 1981

NEC Groups	Sea Billets	% of Sea Billets	Shore Billets	% of Shore Billets
3351/3361	329	5.3	0	0
3353/3363	1295	21.2	225	14.9
3354/3364	1859	30.4	208	13.7
3355/3365	1853	30.3	365	24.2
3356/3366	781	12.8	333	22.0
3359	0	0	382	25.2
TOTAL	6117	100.0	1513	100.0

TABLE XIII

SEA BILLET PROJECTIONS FOR NEC 335X/336X

NEC GROUPS \ FY	81	82	83	84	85	86	87	88	89	90
3351/3361	329	337	347	357	367	371	379	389	399	403
3353/3363	1295	1327	1367	1407	1447	1463	1495	1535	1575	1589
3354/3364	1859	1905	1962	2019	2076	2098	2144	2201	2258	2282
3355/3365	1853	1907	1974	2047	2117	2146	2203	2270	2337	2365
3356/3366	781	801	806	851	876	886	906	931	956	966
3359	0	0	0	0	0	0	0	0	0	0
TOTALS	6117	6277	6476	6681	6883	6964	7127	7326	7525	7605

order to apportion the increases over the various NEC groups, each figure was further multiplied by the percentages of shore billets as listed in Table XII. For example, using 1985 sea billet projections,

(i) # of sea billets in 1985 = 6883

(ii) # of shore billets in 1985

6883 X (1513/6117) = 1703

(iii) apportion shore billets to NEC groups

3351/3361	0	X	1703	=	0
3353/3363	.149	X	1703	=	253
3354/3364	.137	X	1703	=	234
3355/3365	.242	X	1703	=	411
3356/3366	.220	X	1703	=	375
3359	.252	X	1703	=	430

By maintaining the previous assumptions, we have assumed that 335X and 336X NECs will increase proportionately in the out-years yielding a 190 billet increase for shore duty personnel over what was authorized in 1981. Similar calculations were conducted for remaining years with results as displayed in Table XIV.

While shore duty billets have been projected in the out years, the projections remain to be apportioned over the appropriate paygrade and 335X or 336X conventions. The assumption is made at this point that proportional shore billet paygrade assignments will be maintained throughout the next ten years. This process was conducted in two separate manners. The first situation concerns the apportionment of shore duty billets in the NEC 3359 classification. NEC 3359

TABLE XIV

SHORE DUTY PROJECTIONS FOR NEC 335X/336X

NEC GROUP \ FY	81	82	83	84	85	86	87	88	89	90
3351/3361	0	0	0	0	0	0	0	0	0	0
3353/3363	225	231	238	246	253	256	262	269	277	280
3354/3364	208	213	220	227	234	237	242	249	256	259
3355/3365	365	374	386	399	411	415	425	437	449	454
3356/3366	333	342	353	364	375	379	388	399	410	414
3359	382	392	404	417	430	435	445	457	470	475
TOTALS	1513	1552	1601	1653	1703	1722	1762	1811	1862	1882

personnel are shore duty assigned personnel with the following 1981 paygrade assignments:

PAYGRADE	# OF BILLETS	% OF BILLETS
E5	13	3.4%
E6	184	48.2%
E7	122	32.0%
E8	35	9.2%
E9	28	7.2%

In the out years, personnel with NEC 3359 were allocated these percentages of shore duty billets to the associated paygrades.

The second situation encompasses the remaining 335X and 336X NEC personnel. The remaining shore billet assignments were assumed to be distributed proportionately over paygrades according to their relative strengths within groups of NECs as displayed in Tables IX and X.

3. Total Billet Requirements

The final calculation of billet requirements is the sum of sea billet and shore billet requirements as depicted in Tables XV and XVI. Tables XV and XVI are the requirements vector for the associated NECs in any time period. These are the billets that will have to be filled each year to maintain 100% manning levels. The figures listed in these tables will hereby be referred to as the r(t) vector.

C. INPUT REQUIREMENTS

The significant segment of the submariner manpower input model is the determination of inputs required to man the 335X and 336X NEC billets as determined in Tables XV and XVI. To

TABLE XV

TOTAL BILLET REQUIREMENTS PER YEAR FOR NEC 335X PERSONNEL

PAYGRADE \ FY	81	82	83	84	85	86	87	88	89	90
E4	1325	1353	1387	1417	1449	1459	1485	1519	1553	1569
E5	2415	2480	2560	2644	2724	2758	2823	2906	2984	3017
E6	184	189	195	201	207	210	214	220	226	229
E7	122	125	129	133	137	139	142	146	150	152
E8	35	36	37	38	39	40	41	42	43	44
E9	28	29	30	31	32	32	33	33	34	35

TABLE XVI

TOTAL BILLET REQUIREMENTS PER YEAR FOR NEC 336X PERSONNEL

PAYGRADE \ FY	81	82	83	84	85	86	87	88	89	90
E5	8	8	8	8	8	8	8	8	8	8
E6	2562	2638	2735	2840	2940	2980	3062	3158	3254	3292
E7	598	608	625	639	652	658	669	683	696	702
E8	315	326	338	350	362	367	376	388	400	405
E9	38	38	38	38	39	39	39	39	39	40

accomplish this end, the following equation from Cahpter II will be used:

$$f(t) = r(t) - Qs(t-1)$$

where f(t) = the number of personnel to be inputs to the 335X, 336X billets in time t.
r(t) = number of billets to be filled in time t.
Qs(t-1) = legacy left over from previous time periods.

Example of Calculations: (using t = 1981, 335X personnel)

$$f(1981) = r(1981) - Qs(1980$$

$$\begin{matrix} f_1(1981) \\ f_2(1981) \\ f_3(1981) \\ f_4(1981) \\ f_5(1981) \\ f_6(1981) \end{matrix} = \begin{bmatrix} 1325 \\ 2415 \\ 184 \\ 122 \\ 35 \\ 28 \end{bmatrix} - \begin{bmatrix} .228 & 0 & 0 & 0 & 0 & 0 \\ .586 & .589 & 0 & 0 & 0 & 0 \\ 0 & .178 & .342 & 0 & 0 & 0 \\ 0 & 0 & .052 & .451 & 0 & 0 \\ 0 & 0 & 0 & .037 & .578 & 0 \\ 0 & 0 & 0 & 0 & .078 & .571 \end{bmatrix} X \begin{pmatrix} 1086 \\ 4301 \\ 795 \\ 162 \\ 90 \\ 35 \end{pmatrix}$$

In executing the previous calculations, it was stated earlier that feasible input flows must be non-negative. If r(t) - Qs(t-1) is negative, f(t) will be replaced by a zero. The reason for this is that forced attrition is not allowed in the model. Having f(t) = 0 indicates that no new requirements exist for the paygrade in question. Therefore, in solving the previous stated problem,

$$f(t) = \begin{matrix} 1077 \\ 0 \\ 0 \\ 8 \\ 0 \\ 1 \end{matrix}$$

The results of the calculations indicate 1981 input requirements for E4s, E7s and E9s for 335X billets. Similar computations are required on all other projected time periods and for 336X personnel. Prior to computing flows in the out years, a method

must be established for computing the stocks for each time period in order to determine the legacies appropriate for each inflow computation.

D. STOCK DETERMINATION

Stock determination depicts the numbers of personnel in the inventory at the end of the accounting period and is calculated through the following equation:

$$s(t) = f(t) + Qs(t-1)$$

where $s(t)$ = the stocks of personnel by paygrade in time t.
$f(t)$ = the flows of personnel into each paygrade during period t.
$Qs(t-1)$ = the legacy remaining in each paygrade from the previous time period.

Examples of calculations: (using t=1981, 335X personnel)

$$s(1981) = f(1981) + Qs(1980)$$

$$\begin{pmatrix} s_1(1981) \\ s_2(1981) \\ s_3(1981) \\ s_4(1981) \\ s_5(1981) \\ s_6(1981) \end{pmatrix} = \begin{pmatrix} 1077 \\ 0 \\ 0 \\ 8 \\ 0 \\ 1 \end{pmatrix} + \begin{bmatrix} .228 & 0 & 0 & 0 & 0 & 0 \\ .586 & .589 & 0 & 0 & 0 & 0 \\ 0 & .178 & .342 & 0 & 0 & 0 \\ 0 & 0 & .052 & .451 & 0 & 0 \\ 0 & 0 & 0 & .037 & .578 & 0 \\ 0 & 0 & 0 & 0 & .078 & .571 \end{bmatrix} X \begin{pmatrix} 1086 \\ 4301 \\ 795 \\ 162 \\ 90 \\ 35 \end{pmatrix}$$

$$= \begin{matrix} 1325 \\ 3170 \\ 1037 \\ 114 \\ 58 \\ 27 \end{matrix}$$

Identical calculations would be performed on other time periods and the 336X NEC personnel. Tables XVII and XVIII provide input requirements and the computed stock levels of NEC 335X personnel. Tables XIX and XX provide the same information on the NEC 336X personnel.

TABLE XVII

PROJECTED STOCK LEVELS PER YEAR FOR NEC 335X PERSONNEL

Paygrade \ FY	81	82	83	84	85	86	87	88	89	90
E4	1325	1353	1387	1417	1449	1459	1485	1519	1553	1569
E5	3170	2644	2560	2644	2724	2758	2823	2906	2984	3017
E6	1037	919	785	724	718	730	741	756	776	797
E7	114	125	129	133	137	139	142	146	150	152
E8	58	38	37	38	39	40	41	42	43	44
E9	27	29	30	31	32	32	33	33	34	35

TABLE XVIII

PROJECTED INPUT REQUIREMENTS PER YEAR FOR NEC 335X PERSONNEL

Paygrade \ FY	81	82	83	84	85	86	87	88	89	90
E4	1077	1051	1079	1101	1126	1129	1152	1180	1207	1215
E5	0	0	210	324	336	304	344	373	382	340
E6	0	0	0	0	0	0	0	0	0	0
E7	8	20	25	34	39	40	41	43	45	44
E8	0	0	10	12	12	12	13	13	13	14
E9	1	9	10	11	11	11	12	11	12	12

TABLE XIX

PROJECTED STOCK LEVELS PER YEAR FOR NEC 336X PERSONNEL

Paygrade \ FY	81	82	83	84	85	86	87	88	89	90
E5	8	8	8	8	8	8	8	8	8	8
E6	2562	2638	2735	2840	2940	2980	3062	3158	3254	3292
E7	589	792	953	1085	1198	1295	1373	1442	1506	1567
E8	315	326	338	350	362	367	380	396	414	432
E9	44	48	51	54	57	60	62	64	66	69

TABLE XX

PROJECTED INPUT REQUIREMENTS PER YEAR FOR NEC 336X PERSONNEL

Paygrade \ FY	81	82	83	84	85	86	87	88	89	90
E5	4	7	7	7	7	7	7	7	7	7
E6	1224	1314	1372	1427	1473	1461	1523	1577	1747	1680
E7	0	0	0	0	0	0	0	0	0	0
E8	53	47	33	22	13	0	0	0	0	0
E9	0	0	0	0	0	0	0	0	0	0

E. EXPLANATION OF FINDINGS

1. NEC 335X Personnel

Table XVIII depicts the necessary input of personnel to each paygrade in order to man NEC 335X at 100% of authorized manning levels. E4s can be seen to demand a high amount of input in any time period, averaging about 78% of the ten year total inputs. This is quite reasonable as this is the basic entry level paygrade for 335X personnel, usually gaining entry following 'C' school and associated specialty training pipelines. Another explanation for this action is contained in the Q-matrix. At any one time, approximately 22.8% of E4s remain E4s from one accounting period to the next, while 58.6% are promoted to E5s. E5s on the other hand, begin with an excess supply of personnel and continue as such until about 1983, despite the large influx of personnel from the E4 ranks.

Petty Officers First Class and above reflect NEC 3359 and are authorized for shore duty billets only. All billet requirements for these paygrades are caused by pure increases in shore billets. E6 input requirements are shown as zeros indicating an excess supply of personnel to billets. It should be noted from the Q-matrix in Table IV that E6s have the highest loss rate. One explanation for this is the high number of E6s who have their NECs re-designated to a 336X series as the operator becomes a qualified supervisor.

2. NEC 336X Personnel

Table XX reflects total requirements for personnel coded with a 336X primary NEC. Ship Manning Documents do not reflect a sea billet for E5 so it is assumed that 336X E5 personnel are assigned shore duty billets, and are therefore not expected to increase over the next ten years. E6s are the major element in the 336X NEC and reflect consistent requirements for trained personnel to fill these billets. The majority of personnel filling E6 336X billets are accessed directly from the associated 335X billets. Once again, depending mainly on the Q-matrix, Chief Petty Officer paygrades require no input to fully man the 336X billets in the out years.

V. CONCLUSIONS

The submariner manpower input model has been applied to two blocks of NECs to yield the total requirements for personnel by paygrade up to 1990. The key element for forecasting figures is the model's reliability upon a Q-matrix. While this model developed a Q-matrix based on one year's data, it would have been better to base the Q upon longitudinal data sets. The Q-matrix in this case was based upon 1980 data when the issue of large pay raises may have inflated Q-matrix data, i.e., personnel remaining in the service may be overstated.

The model is intended to provide some insight to manpower planners on aspects to consider in forecasting future input. Knowing what the future input is for the E4, E5 paygrades, it may be possible to determine the future input to the Navy for general seamen and firemen. Training pipelines, loads, attrition rates would be additional information required for this attempt.

In conclusion, the model has been demonstrated. The concepts of matricis and vector manipulation has been exercised. While the model has been applied to only two sets of NECs, it could easily be adapted to any rate, rating or NEC. Determination of future inputs to any segment of the military system is most important in an era of economic uncertainties and manpower shortages not only because it will indicate the numbers of

people required to fill billets, but also because it indicates where the weaknesses are in areas of reenlistment and manpower excesses. It is with this purpose in mind that the submariner manpower input model has been presented.

The future projections extracted from the model depend heavily on the degree to which the Q-matrix represents normal movement of personnel within a fiscal year time frame. Assuming that the Q-martices developed for 335X and 336X personnel is indicative of future paygrades, the model results reveal several points of interest. In evaluating the 335X series personnel, Table XVIII reveals no input requirements for paygrade E6. On the other hand, projected stock levels for E6s far outnumber the authorized billets allotted for E6s, indicating a severe under-utilization of personnel. All other 335X paygrades display a full utilization of personnel as stock levels are evenly matched with numbers of authorized billets in the out years.

The Q-matrix for 336X personnel displays high amounts of personnel at the E7, E8, and E9 paygrades who choose to remain in the Navy as 336X coded personnel. Future projections reveal large inventories of these paygrades and not so large number of billets authorized for these personnel. Once again, a severe under-utilization of personnel is realized.

While input requirements remain numerous for lower grade petty officers, possibilities exist to substitute higher grade petty officers into junior billets, or increase the numbers of

senior enlisted billets authorized in the out years. Under-utilization of personnel at a time when manpower resources are dwindling in supplies compounds the Navy's situational problems of manning a fifteen battle group Navy.

APPENDIX A

SEA BILLET AUTHORIZATIONS

The following tables provide billet authorizations for 335X and 336X personnel by classes of submarine. Data was compiled from summaries of organizational manpower requirements in the Ship Manning Documents and only contain sea billet authorizations.

TABLE A-I

BILLET AUTHORIZATIONS FOR SSN 575 CLASS

NEC	Paygrade Rate	E4	E5	E6	E7	E8	E9
3351	MM		1				
3353	ET	2	3				
3354	EM	2	2				
3354	IC	1	1				
3355	MM	3	2				
3356	MM		3				
3361	MM			2			
3363	ET			2	1		
3364	EM			3		1	
3364	IC			1			
3365	MM			3	1	1	
3366	MM			2			

TABLE A-II

BILLET AUTHORIZATIONS FOR SSN 578 CLASS

NEC	Paygrade Rate	E4	E5	E6	E7	E8	E9
3351	MM		1				
3353	ET	2	3				
3354	EM	2	2				
3354	IC	1	1				
3355	MM	3	2				
3356	MM		3				
3361	MM			2			
3363	ET			2	1		
3364	EM			3		1	
3364	IC			1			
3365	MM			3	1	1	
3366	MM			2			

TABLE A-III

BILLET AUTHORIZATIONS FOR SSN 585 CLASS

NEC	Paygrade Rate	E4	E5	E6	E7	E8	E9
3351	MM		1				
3353	ET	2	3				
3354	EM	2	2				
3354	IC	1	1				
3355	MM	4	2				
3356	MM		3				
3361	MM			1			
3363	ET			2	1		
3364	EM			4		1	
3364	IC			1			
3365	MM			3	1	1	
3366	MM			2			

TABLE A-IV

BILLET AUTHORIZATIONS FOR SSN 594 CLASS

NEC	Paygrade Rate	E4	E5	E6	E7	E8	E9
3351	MM		1				
3353	ET	2	3				
3354	EM	2	2				
3354	IC	1	1				
3355	MM	3	3				
3356	MM		3				
3361	MM			1			
3363	ET			2	1		
3364	EM			4		1	
3364	IC			1			
3365	MM			3	1	1	
3366	MM			2			

TABLE A-V

BILLET AUTHORIZATIONS FOR SSN 597 CLASS

NEC	Paygrade Rate	E4	E5	E6	E7	E8	E9
3351	MM		1				
3353	ET	2	3				
3354	EM	2	2				
3354	IC	1	1				
3355	MM	3	3				
3356	MM		3				
3361	MM			1			
3363	ET			2	1		
3364	EM			4		1	
3364	IC			1			
3365	MM			3	1	1	
3366	MM			2			

TABLE A-VI

BILLET AUTHORIZATIONS FOR SSN 598 CLASS

NEC	Paygrade Rate	E4	E5	E6	E7	E8	E9
3351	MM		1				
3353	ET	2	3				
3354	EM	2	2				
3354	IC	1	1				
3355	MM	4	2				
3356	MM		3				
3361	MM			1			
3363	ET			1	1		
3364	EM			2	1		
3364	IC			1			
3365	MM			2	1	1	
3366	MM			1			

TABLE A-VII

BILLET AUTHORIZATIONS FOR SSN 608 CLASS

NEC	Paygrade Rate	E4	E5	E6	E7	E8	E9
3351	MM		1				
3353	ET	2	3				
3354	EM	2	2				
3354	IC	1	1				
3355	MM	4	2				
3356	MM		3				
3361	MM			1			
3363	ET			1	1		
3364	EM			2	1		
3364	IC			1			
3365	MM			2	1	1	
3366	MM			1			

TABLE A-VIII

BILLET AUTHORIZATIONS FOR SSN 637 CLASS

NEC	Paygrade Rate	E4	E5	E6	E7	E8	E9
3351	MM		1				
3353	ET	2	3				
3354	EM	2	2				
3354	IC	1	1				
3355	MM	3	3				
3356	MM		3				
3361	MM			1			
3363	ET			2	1		
3364	EM			4		1	
3364	IC			1			
3365	MM			3	1	1	
3366	MM			2			

TABLE A-IX

BILLET AUTHORIZATIONS FOR SSN 671 CLASS

NEC	Paygrade Rate	E4	E5	E6	E7	E8	E9
3351	MM		1				
3353	ET	1	3				
3354	EM	1	2				
3354	IC	1	1				
3355	MM	3	3				
3356	MM		3				
3361	MM			1			
3363	ET			3	1		
3364	EM			4		1	
3364	IC			1			
3365	MM			5	1	1	
3366	MM			2			

TABLE A-X

BILLET AUTHORIZATIONS FOR SSN 685 CLASS

NEC	Paygrade Rate	E4	E5	E6	E7	E8	E9
3351	MM		1				
3353	ET	1	3				
3354	EM	1	2				
3354	IC	1	1				
3355	MM	3	3				
3356	MM		3				
3361	MM			1			
3363	ET			3	1		
3364	EM			4		1	
3364	IC			1			
3365	MM			5	1	1	
3366	MM			2			

TABLE A-XI

BILLET AUTHORIZATIONS FOR SSN 688 CLASS

NEC	Paygrade Rate	E4	E5	E6	E7	E8	E9
3351	MM		1				
3353	ET	1	3				
3354	EM	1	2				
3354	IC	1	1				
3355	MM	3	3				
3356	MM		3				
3361	MM			1			
3363	ET			3	1		
3364	EM			4		1	
3363	IC			1			
3365	MM			5	1	1	
3366	MM			2			

TABLE A-XII

BILLET AUTHORIZATIONS FOR SSBN 616 CLASS

NEC	Paygrade Rate	E4	E5	E6	E7	E8	E9
3351	MM		1				
3353	ET	2	3				
3354	EM	2	2				
3354	IC	1	1				
3355	MM	4	2				
3356	MM		3				
3361	MM			1			
3363	ET			1	1		
3364	EM			2	1		
3364	IC			1			
3365	MM			2	1	1	
3366	MM			1			

Note: SSBNs have two crews per submarine.

TABLE A-XIII

BILLET AUTHORIZATIONS FOR SSBN 726 CLASS

NEC	Paygrade Rate	E4	E5	E6	E7	E8	E9
3351	MM		1				
3353	ET	1	3				
3354	EM	2	2				
3354	IC	1	1				
3355	MM	4	3				
3356	MM		3				
3361	MM			1			
3363	ET			3	1		
3364	EM			4		1	
3364	IC			1			
3365	MM			5	1	1	
3366	MM			2			

Note: SSBNs have two crews per submarine.

LIST OF REFERENCES

1. Navy Enlisted Manpower and Personnel Classifications and Occupational Standards, NAVPERS 18068D, Chief of Naval Personnel, Washington, D.C., April 1981.

2. Grinold, Richard C. & Kneale T. Marshall, Manpower Planning Models, Elsevier North-Holland, New York, 1977.

3. Cunningham, A., YNC(SS), Personal Communications, Naval Military Personnel Center, Washington, D.C., December 1981.

INITIAL DISTRIBUTION LIST

		No. Copies
1.	Defense Technical Information Center Cameron Station Alexandria, Virginia 22314	2
2.	Library, Code 0142 Naval Postgraduate School Monterey, California 93940	2
3.	Department Chairman, Code 54 Department of Administrative Sciences Naval Postgraduate School Monterey, California 93940	1
4.	Professor Kneale Marshall, Code 55mt Department of Operations Research Naval Postgraduate School Monterey, California 93940	1
5.	Professor Richard Elster, Code 54Ea Department of Administrative Sciences Naval Postgraduate School Monterey, California 93940	6
6.	Deputy Chief of Naval Operations (Manpower, Personnel and Training) Chief of Naval Operations, OP-01, OP-11, OP-12, OP-13 Arlington Annex Columbia Pike and Arlington Ridge Road Arlington, Virginia 20370	4
7.	LT Lawrence K. C. Doong RR 1, Box 716 Kula, Hawaii 96790	1
8.	Professor George Thomas, Code 54Te Department of Administrative Sciences Naval Postgraduate School Monterey, California 93940	1
9.	Defense Logistics Studies Information Exchange U. S. Army Logistics Management Center Fort Lee, Virginia 23801	2

Thesis
D6525
c.1

Doong

A manpower model to determine future inputs to NEC 335X and NEC 336X billets.

195691

31 AUG 84

29548
33126
30340
36546

Thesis
D6525
c.1

Doong

A manpower model to determine future inputs to NEC 335X and NEC 336X billets.

A manpower model to determine future inp
3 2768 002 00605 8
DUDLEY KNOX LIBRARY